Internet of Things (IoT) at UCF

UNIVERSITY OF CENTRAL FLORIDA

UCF RET Site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers

Physical Science Honors

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Physical Science Honors

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RET Site: Sensing Energy Transformations with Circuit Design Lesson Plan

Subject Area(s): Physical Science
Course(s): High School Physical Science Honors
Grade Level: 9-12
Suggested Length of Lesson: 2-3 Days

Lesson Summary: Students gain a basic knowledge of sensors and their current applications, design their own circuits, and connect their circuits to power sources and various lamps. Students utilize sensory technology present in their cellphones to determine the transfer of energy from the power source and circuit to lumens.

Prerequisite Knowledge: Students should understand the fundamentals of energy transformations, electromagnetic waves, work, and power.

Materials/Technology Needed
- Cell phone
- Cell phone application "Lux Meter (Light Meter)", My Mobile Tools Dev
- Conductive ink pens
- Plastic transparency film and/or card stock
- Alligator clips
- Batteries (C, D or 9V recommended)
- Battery connection sets
- Lamps (LED, incandescent, etc.)
- Paper
- Pencil
- Measurement device
- Dye cutter/scanning machine and accessories (optional)

Where this Fits/Lesson Dependency
- Energy
  - SC.912.P.10.1
  - SC.912.P.10.2
  - SC.912.P.10.6

Standard(s)/Benchmark(s) Addressed (2-4)
- *Standards:*
  - SC.912.P.10.1 - Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.
  - SC.912.P.10.2 - Explore the Law of Conservation of Energy by differentiating among open, closed, and isolated systems and explain that the total energy in an

<table>
<tr>
<td>Lesson Objective(s)/Learning Goal(s) (2-4)
▪ Students can design, test, and evaluate sensors for use in transferring energy from one device to another
▪ Students can describe the transformation of energy in terms of sensor technology within a device</td>
<td>isolated system is a conserved quantity.
▪ SC.912.P.10.6 - Create and interpret potential energy diagrams, for example: chemical reactions, orbits around a central body, motion of a pendulum.</td>
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<tr>
<td>Standards for Mathematical Practice
▪ MA.6.A.3.6 - Construct and analyze tables, graphs, and equations to describe linear functions and other simple relations using both common language and algebraic notation.
▪ MA.8.A.1.1 - Create and interpret tables, graphs, and models to represent, analyze, and solve problems related to linear equations, including analysis of domain, range, and the difference between discrete and continuous data.
▪ MA.3.G.5.2 - Measure objects using fractional parts of linear units such as 1/2, 1/4, and 1/10.</td>
<td rowspan="2">Instructional Strategies
▪ Think-Pair-Share
▪ Cooperative Learning
▪ Inquiry-Based Instruction
▪ Socratic Questioning
▪ Engineering Design Challenge</td>
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<td>Evidence of Learning (Assessment Plan)
▪ Formal Formative and Summative Written Responses:
o In your own words, explain how energy is transferred in a sensor system. Draw a diagram.
Does the size/length of the circuit matter?</td>
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How could physical aspects of the sensors affect the amount of light produced by the lamp?	

Description of Lesson Activity/Experiences

1. Students are presented with a problem to solve:
    a. *Option 1*: You are (or are working for) an artist who needs to shine light on their art piece with minimal heat transfer because heat could damage the artwork. To get the effect needed, the lumens produced by your light need to be between 400-450 lux.
    b. *Option 2*: You are trying to repair an illuminator, a medical device used for viewing x-rays, and you need a lamp to produce light with a lumen range between 350-400 lux.
    c. *Option 3*: You are an interior designer and need to develop a minimally invasive lighting system so that your customer can easily see items on their kitchen counters, display shelves, and their house numbers on the front of their home. The lumen range needs to be between 450-550 lux.
2. Student engineers design a draft of their own circuits using paper and pencil to sketch out their ideas. Teacher provides feedback as related to circuit functionalities and requirements.
3. Engineers collaborate with their shoulder partners to improve their individual designs or combine their designs. Teacher provides feedback as related to circuit functionalities and requirements.
4. Engineers collaborate with their table group (4-5 students) to develop two circuits with their idea of ideal features and create their final drafts of their group designs. Teacher provides feedback as related to sensor functionalities and requirements.
5. Development of conductive circuits using conductive ink pens:
    a. *With Dye Cutter/Scan Design Machine:*
    Instructor approves designs and scans final drafts into the dye cutter/scanner machine, ensures cleanliness of scan, and processes conductive ink drawing of design through machine.
    b. *Manual:*
    Instructor approves designs and provides engineers with conductive ink pens to finalize the design process of the sensors.

6. Engineers allow sufficient dry time for the conductive sensors.
7. Engineers test their sensors:
    a. Apply a power source (battery, battery adapter, alligator clips) to the sensors.
    b. Connect a lamp (LED recommended)
8. Engineers compare group designs in relation to the energy transfer between the power source and the light source by collecting data:
    a. Qualitative data collection: apparent luminosity difference between each sensor; visual evaluation of the differences between the amount of conductive material used in each sensor
    b. Quantitative data collection: comparison of max and average values of lumens produced by the lamps as determined utilizing the Lux Meter (Light Meter) application by My Mobile Tools Dev; measurement of the length and width of the drawn circuit
9. Engineers draw conclusions relating energy transfer from the power source to the light source with specific reference to the qualitative and quantitative data collected.

Recommended Assessment(s) and Steps

- Formative Formal Assessment:
    - Written responses:
      In your own words, explain how energy is transferred in a sensor system. Draw a diagram.
      Does the size/length of the sensor matter?
      How could physical aspects of the sensors affect the amount of light produced by the lamp?
- Informal Assessment:
    - Think-Pair-Share
    - Periodic critique of designs
- Summative Formal Assessment:
    - Written responses (looking for gains):
      In your own words, explain how energy is transferred in a sensor system. Draw a diagram.
      Does the size/length of the sensor matter?
      How could physical aspects of the sensors affect the amount of light produced by the lamp?

List of Materials/Resources Used

- Cell phone
- Cell phone application "Lux Meter (Light Meter)", My Mobile Tools Dev
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- Alligator clips
- Batteries (D recommended)
- Battery connection sets
- Lamps (LED, incandescent, etc.)
- Measurement device (ruler, tape measure, string to ruler method, etc.)

Engineering Connection (60-100 words/3 sentences)

Students engineer their own individual circuit designs. They collaborate with partners to enhance their designs as a group and settle on two final designs that vary. Students then utilize a designated sensor system to evaluate the power output of their systems. Students make connections between their process and the processes utilized in modern technological practice, citing specific real-world concepts.

Engineering Category (choose one)

	relating science and/or math concepts to engineering (primarily science & math with some engineering)
	engineering analysis or partial design (primarily engineering with some science/math)
x	engineering design process (full engineering design)

Key Words

Electrical Sensors	Energy Transfer	Energy Output
Lux Lumen Light	Circuit Design	Energy Input

Introduction/Motivation (written as if talking to students)

"Sensors are integrated into everyday life in ways we almost never think about. They are used to turn our lights off and on, to detect movement for home security, to test the water that we drink and make sure it is safe. More relevant to you, sensors are used in our cellphones to help us achieve our goals. There are all types of sensors in there, from pressure sensors that help you type to light sensors that determine screen brightness, and even capacitive biometric sensors that can detect our fingerprints or facial features for security purposes. In this lab, we will investigate one type of sensor that could be used in a device to produce a light output."

Lesson Closure (written as if talking to students) Socratic Discussion key building questions: • How do you think this type of technology is applied inside of your cellphone? • Thinking of your cellphone, how would it be helpful for sensors to be made smaller? • Considering the differences you noticed in how much conductive ink was used and the results you got, how do you think the physical design could make a difference? • What are some other real life applications of sensors? Electrical sensors or otherwise. "Electrical circuits and sensors like the ones we have used in this lab are actively used in our world. They are grouped with other sensors and circuits of both similar and different types and help us achieve advanced technological goals."
Lesson Background & Concepts for Teachers • Uses of sensors in modern technology • Basic circuit and sensor design

Important Vocabulary

Term	Definition
Conductivity	How easily electrons move through a given material; Opposite to resistivity
Resistivity	Measure of the ability of a given material to prevent the flow of an electric current; Opposite to conductivity
Conduction	Energy transfer through direct contact
Convection	Energy transfer through a liquid or gas
Radiation	Energy transfer from electromagnetic waves
Lamp	Device for giving light
Light Emitting Diode (LED)	Semi-conductor diode for giving light; Type of lamp
Electrical Energy	Energy caused by moving electrons
Mechanical Energy	Energy of motion used to do work; the sum of potential and kinetic energy
Radiant Energy	Energy supplied by electromagnetic waves
Lumen	Standard International (SI) unit of how much light is given off per second from one light source
Circuit	A closed path that allows electricity to flow from one point to another

Troubleshooting Tips

- Have multiple types of conductive ink pens available and on hand (C, Ag, Ni, etc.), in case there are any conductivity or drying issues.
- Different brands of conductive ink pen function differently, so be sure to test them on the primary material (transparency, card stock, etc.) before lesson use.
- If possible, ensure that at least one student per group has an Android phone for access to the appropriate application free of charge.

Other Helpful Information

- Have students download and experiment with the Android light sensor application prior to the lesson.
- Adjust Engineering Design Challenge problem options according to your student's interests.
- Lumen ranges should be adjusted to accommodate different lighting situations. It is recommended that device lumen production be measured with the lights off, ideally one at a time or with LED's at a great distance apart to reduce interference.

Attachments

- Sensing Energy Transformations with Circuit Design Lab (Google Form)
- "Lux Meter (Light Meter)" Android application by Mobile Tools Dev

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